COMPARATIVE VALUE OF GRAIN SORGHUM SILAGE, DEHYDRATED GRAIN SORGHUM PELLETS, CRACKED SORGHUM GRAIN, AND FINELY GROUND PELLETED SORGHUM GRAIN IN BEEF CATTLE RATIONS

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INTRODUCTION

Grain sorghums are becoming an increasingly important part of Kansas agriculture since they are now being widely used as both a cash crop and as a feed for livestock. Reductions in wheat acreages have meant that the farmer must find an additional enterprise or enterprises that will help maintain his income. Many farmers wisely planted part of their wheat-diverted acreage in grain sorghums for either a cash crop, or for feed to be utilized by an increased livestock enterprise. Grain sorghums have proven to be more consistent in making a crop than corn under most Kansas conditions, so they have therefore become the principal grain grown for livestock feeding except along the northern border of Kansas where corn can be profitably grown.

Many feeding experiments have been conducted to compare sorghum grain with corn for feeding to livestock. These experiments have shown that corn and sorghum grains produce similar gains with similar efficiency. However, sorghum grains are usually lower in price than corn and, consequently, usually produce more economical gains.

Combine-type grain sorghum is widely grown in Kansas. Excessive moisture at harvest may necessitate artifically drying the grain before storage. An early freeze, or delayed planting in the spring, may result in an immature crop in the fall.

Several feeding trials have compared the value of pelleted feeds with the more conventional methods of feed preparation and with whole grains. These trials have been conducted in order to find the physical form of the grain which will result in the highest feed efficiency.

The purpose of this experiment was to determine the comparative value of combine-type grain sorghum harvested as silage or dehydrated and pelleted, and to compare pelleted sorghum grain with cracked sorghum grain in wintering and

fattening rations for beef cattle.

REVIEW OF LITERATURE

Many studies have been conducted in attempting to increase feed efficiency and to decrease cost of gains. Utilization of different methods of preparation of feeds and use of more economical feeds have been extensively studied.

Cattle

Richardson et al. (39) conducted a series of experiments comparing corn with milo grain in the fattening rations of beef cattle. Rate of gain varied in individual tests, but the average rate of gain from three experiments showed corn to be only slightly superior to milo grain. Animals fed corn averaged gaining 2.20 pounds per day, while those fed milo grain averaged 2.18 pounds per day. The average daily consumption of milo grain was greater than corn in all tests. Thus, on a pound for pound basis, corn was more efficient. The increased milo consumption also indicated that it was slightly more palatable.

The cattle went on full feed more quickly and with fewer digestive disturbances when fed milo grain. Although fewer pounds of corn were needed to produce 100 pounds of gain, milo grain was more economical in producing gains because of the lower relative price for milo grain that prevailed during the experiment. There were no appreciable differences in dressing percentage, carcass grade, or degree of marbling in cattle on the different grain rations.

In work at the Nebraska Agriculture Experiment Station, Loeffel (28) reported that ground sorghum grain was 90 to 95 per cent as valuable as corn in beef cattle rations. In trials where ground sorghum grain or corn were fed at the rate of four to five pounds per head daily with alfalfa hay to wintering

calves, the calves fed corn made larger and more efficient gains. Ground sorghum grain in these trials proved to be 93 per cent as valuable as corn on a pound for pound basis. In similar trials where corn silage replaced the alfalfa hay and where an oilseed meal and mineral were fed, sorghum grain proved to be worth 95 per cent as much as corn. In a single experiment where a mixed corn and sorgo silage, cottonseed cake and alfalfa hay were fed, the calves fed sorghum grain made slightly larger and more efficient gains than those fed corn.

In fattening tests, yearling steers fed cracked corn gained more rapidly than similar steers fed cracked sorghum grain. Steers fed corn had a higher dressing percentage and yielded a higher percentage of choice carcasses than those fed sorghum grain. In these tests the sorghum grain proved to be 90 per cent as valuable as corn.

Heifer calves on a fattening ration were fed cottonseed cake and corn silage with either cracked corn or cracked sorghum grain in seven different feeding trials. The average daily gains were identical, but more sorghum grain was consumed per day. The sorghum grain in these comparisons proved to be 93 per cent as efficient as corn. Heifers fed corn dressed slightly higher and graded slightly better as carcasses on the rail.

Richardson et al. (41) conducted an experiment to compare the value of corn, rolled sorghum grain, and pelleted sorghum grain in fattening rations for steers. Steers that received rolled corn had the best rate of gain, feed efficiency, and carcass grade, while steers fed pelleted sorghum grain were superior to steers fed rolled sorghum grain. Grain consumption was kept the same for all lots of steers. In addition the steers were fed one pound of soybean oil meal, two pounds of alfalfa hay and all the sorghum silage that they would eat daily. Steers fed the pelleted sorghum grain produced 100

pounds gain for the lowest cost.

Later work by Richardson et al. (40) compared the value of cracked corn with different physical forms of sorghum grain in wintering and fattening rations for steer calves. The wintering ration consisted of one pound of soybean oil meal, five pounds of grain, two pounds of alfalfa hay, and all the sorghum silage they would clean up daily. Grain used in the different lots were: lot 1, rolled sorghum grain; lot 2, cracked corn; lot 3, finely-ground pelleted sorghum grain; and lot 4, finely-ground sorghum grain. The fattening ration was the same except silage was removed after 32 days. An attempt was made to maintain the same level of grain in all lots. The wintering phase was for 100 days and the fattening phase lasted 138 days.

Rate of gain and feed efficiency during the wintering phase of the test were exceptionally good. Steers fed rolled sorghum grain and pelleted sorghum grain gained the most per day and at the lowest cost per 100 pounds gain. During the fattening phase of the test, the steers that received finely-ground sorghum grain produced the highest average daily gain at the lowest cost. Despite a severe outbreak of foot rot in the lot fed pelleted sorghum grain, they ranked second in economy of gain produced. Feed costs per 100 pounds of gain for both phases of the test were $15.67, $15.27, $14.17, and $13.84, respectively.

✓ Pope et al. (38) used twenty choice Hereford heifer calves averaging nearly 500 pounds to study the value of rolled milo and finely ground pelleted milo in fattening rations. The daily ration consisted of a full-feed of milo (either rolled or pelleted), one and one-half pounds of cottonseed meal, one pound of dehydrated alfalfa meal pellets, and approximately eleven pounds of sorghum silage.

Heifers fed pelleted milo made an average daily gain of 2.17 pounds as

compared with 2.09 pounds average daily gain for heifers fed rolled milo. The pelleted milo proved slightly less palatable than rolled milo with average daily feed intake being 0.47 pound lower. Heifers fed rolled milo averaged consuming 11.96 pounds per day.

Feeding pelleted milo reduced the amount of grain required per 100 pounds of gain by about eight per cent, and reduced the feed cost per 100 pounds of gain by $0.60 per 100 pounds. Heifers fed pelleted milo averaged $0.96 per 100 pounds higher in their appraised value. The total of these advantages resulted in an increased net return of $11.15 per head for heifers fed pelleted milo.

Weir et al. (46), in tests at the University of California, fed steers on pelleted or long alfalfa hay free choice in a feeding trial for 167 days. Each steer also received two pounds of barley and two pounds of long oat hay daily. Steers fed the pelleted hay gained 2.17 pounds per day as compared to 1.80 pounds per day for the steers fed the long alfalfa hay. Carcass data indicated that all animals had reached satisfactory market condition on a minimum of grain. Daily feed intake and feed efficiency were higher for the steers fed pellets. In this study, the level of barley fed constituted only about 10 per cent of the average daily ration.

In another test of 152 days, pelleted and meal rations containing zero, 30 and 60 per cent concentrates were compared as feed for fattening rations. The concentrate portion of the ration consisted of 75 per cent barley and 25 per cent molasses dried beet pulp. Pellets were prepared by grinding the alfalfa hay and barley, mixing the molasses dried beet pulp with the other feeds, and pelleting through a ¼-inch die. The non-pelleted ration was ground through a 3/4-inch or one-inch screen in a hammer mill. A limited amount of long oat hay was fed to all lots with the average daily consumption being 0.52

pound of dry matter.

Average daily gain for the lots fed alfalfa hay with no added concentrates were 2.22 and 1.75 pounds per day for the pelleted and meal rations, respectively. With 30 per cent concentrates in the ration, steers fed pellets gained 2.29 pounds per day as compared to 2.07 pounds per day for the steers fed meal. Steers on the pelleted 60 per cent concentrate ration gained 2.14 pounds per day, while those fed meal gained 2.46 pounds per day. Steers on pelleted rations showed highly significantly larger gains without added concentrates, showed no significant difference in gains with 30 per cent concentrates, and were significantly lower in gains on the 60 per cent concentrate ration. Carcass grades indicated that all steers were in acceptable slaughter condition except the lot fed alfalfa meal.

At the Dixon Springs Station of the University of Illinois, Webb et al. (45) compared the value of different methods of harvesting and preparing a timothy-alfalfa mixture when fed as the wintering ration to steer calves. The timothy-alfalfa mixture was harvested as silage or baled hay, and the baled hay was later ground and pelleted, chopped, or left in the long state. Calves were divided into four lots and received either baled hay, silage plus chopped hay, hay pellets, or chopped hay. Average daily gains were 0.63, 0.05, 1.73, and 0.62 pounds per day, respectively, for the various forms of roughage. The silage was of poor quality and resulted in very low gains and very poor feed efficiency. Dry matter intake was much higher with the calves that received hay pellets. Feed efficiency of the hay pellets was quite outstanding with 825 pounds of dry matter required per 100 pounds gain. Calves fed baled hay required 1498 pounds of dry matter per 100 pounds gain, compared with 1492 pounds of dry matter for calves fed chopped hay. Calves fed silage and chopped hay needed 13,505 pounds of dry matter to produce 100 pounds gain.

A later experiment at Dixon Springs was conducted with 90 steer calves being wintered for 112 days on the following roughages: alfalfa hay pellets, alfalfa hay pellets plus rumen additive, timothy-alfalfa hay pellets, Sericea lespedeza hay pellets, baled alfalfa hay, baled alfalfa hay plus rumen additive, timothy-alfalfa silage plus long hay, timothy-alfalfa silage plus long hay plus rumen additive, and baled Sericea lespedeza hay. Average daily gains were 1.77, 1.82, 1.33, 0.38, 0.18, 0.43, 0.30, 0.27, and 0.21 pounds per day, respectively. Efficiency of the various roughages again greatly favored the hay pellets.

Boren et al. (12) conducted an experiment with fifty choice heifer calves averaging 403 to 406 pounds. They were wintered on alfalfa hay fed in the long form or as pellets, and forage sorghum fed as silage or dehydrated pellets. Lot 1 received five pounds alfalfa hay plus sorghum silage free choice, lot 2 was fed five pounds alfalfa pellets plus sorghum silage free choice, lot 3 received five pounds alfalfa hay plus dehydrated sorghum pellets free choice, lot 4 received five pounds alfalfa pellets plus dehydrated sorghum pellets free choice, and lot 5 was fed five pounds alfalfa pellets plus dehydrated sorghum pellets free choice plus one pound prairie hay.

Results showed satisfactory gains in all lots. The percentage increase in average daily gain over the control heifers in lot 1 were 20, 28, 50, and 43 per cent, respectively. Receiving either form of roughage pelleted resulted in increased dry matter intake and increased rate of gain. Dehydrating and pelleting the forage-type sorghum caused the greatest increase in dry matter intake. Because of the high cost of dehydrating the forage-type sorghum, all lots receiving dehydrated sorghum pellets showed a higher cost per 100 pounds gain.

Brethour and Duitsman (13) conducted an experiment to determine whether

it was feasible to salvage a crop of grain sorghum by ensiling either the heads or the entire grain sorghum plant as feed for fattening yearling steers. The grain was in the soft-dough stage and averaged 51 per cent moisture when ensiled. Special equipment harvested the grain sorghum heads and they were then chopped at the silo by a stationary cutter. Check areas were left until the grain reached maturity when it was combined. The average grain yield was 95.5 bushels per acre on a 12 per cent moisture basis.

Three lots were fed in this experiment. One lot received one part rolled sorghum grain to two parts Ellis sorgo silage. The second lot received grain sorghum head silage, while the third lot received 0.20 pound rolled sorghum grain with each pound of the whole plant grain sorghum silage. This method gave the same ratio of grain to roughage for each of the three lots. Ellis sorgo silage was mixed with the grain sorghum silages during the first five to seven weeks of the trial in bringing the steers to full feed. The daily ration was supplemented by three pounds of alfalfa hay and one and one-half pounds of cottonseed meal. Aureomycin was mixed with the cottonseed meal to provide 72 milligrams per head daily. Each steer also received a 36 milligram implant of stilbestrol.

Results show that the steers fattened on the sorghum grain head silage gained less than those in the other two lots. Although the head silage was preserved well, it was not chopped as finely as silage harvested in the field. A large quantity of coarse, ragged material was refused and dry matter intake was not so great as it was in the other lots. The steers fed grain sorghum silage supplemented with sorghum grain were equal in rate of gain, yield, and grade to those fed a ration of one part sorghum grain to two parts Ellis sorgo silage.

Baker et al. (10) self fed a fattening ration in pelleted and non-pelleted

forms to twenty yearling heifers of good to choice quality. The lot on the non-pelleted ration had coarsely cracked corn, cottonseed meal, blackstrap molasses, and chopped alfalfa hay blended together. Since a previous experiment by Baker et al. (9) had indicated that heifers fed a completely pelleted ration made inferior gains and had lower carcass grades and dressing percentages, the lot fed pellets in this trial also received one and one-half pounds of alfalfa hay per head daily in order to satisfy the craving for coarse roughage exhibited in the previous trial. A lack of rumination had also been previously experienced. For the first 43 days of the 113-day fattening period, the pelleted ration contained 65 per cent corn, 25 per cent alfalfa hay, 5 per cent molasses, and 5 per cent cottonseed meal. During the last 70 days the corn content of the pellets was increased to 70 per cent and the alfalfa hay content was decreased to 20 per cent.

Feed efficiency was significantly improved by pelleting the ration. Rate of gain, rumination, and the general feed-lot performance were normal for the heifers fed the pelleted ration and a small quantity of alfalfa hay. This small quantity of coarse roughage appeared essential in obtaining a normal rate of gain and feed-lot performance from cattle fed pelleted rations. Average daily gain for heifers on the non-pelleted ration was slightly higher, but the cost per 100 pounds gain was more economical for the heifers on the pelleted ration.

Kercher and Hilston (25) compared pelleted and non-pelleted rations and pelleted rations with varying roughage to concentrate ratios in fattening rations for 56 yearling steers averaging 864 pounds. For the feeding period of 114 days, corn silage was fed to all groups at a constant rate with the balance of the ration fed free choice. The free choice portion of the ration for the different lots was composed as follows: 50:50 mixture of alfalfa and

concentrates fed non-pelleted; 50:50 mixture of alfalfa and concentrates fed as pellets; 70:30 mixture of alfalfa and concentrates fed pelleted; and a 70 per cent alfalfa, 20 per cent concentrates, and 10 per cent tallow mixture fed pelleted.

Pelleting the hay and grain ration significantly increased the daily gain. The average daily gain of the different lots were 2.22, 2.92, 2.86, and 2.69 pounds per day, respectively. The level of roughage in the pellet or the inclusion of animal tallow in the pellet did not significantly influence feedlot gains. There were no significant differences in the amount of feed required for 100 pounds of gain, or in the carcass yield or carcass score.

Cmarik et al. (15) studied the response of fattening yearling steers when self-fed complete pelleted rations of varying ratios of concentrate to roughage. Sixty steers weighing 700 pounds were divided into four lots and fed the following pelleted rations for a period of 153 days: lot 1, 65 per cent ground shelled corn, 25 per cent ground hay, 10 per cent soybean oil meal; lot 2, 55 per cent corn, 35 per cent hay, 10 per cent soybean oil meal; lot 3, 45 per cent corn, 45 per cent hay, 10 per cent soybean oil meal; and lot 4, a pellet containing the same composition as lot 2 except that all ingredients were ground extremely fine before pelleting.

Average daily gains for the various lots were 2.89, 2.85, 2.71, and 2.63 pounds per day, respectively. Total digestible nutrients required per 100 pounds gain were 524.5, 536.2, 541.4, and 553.7 pounds, respectively. The workers thus concluded that roughage can satisfactorily make up a relatively high per cent of a fattening ration if offered in a form readily acceptable to the steer. No ill effects were noted in the steers in lot 4 which were fed the ration that was ground extremely fine before pelleting.

Sheep

Cox and Bell (16) stated that sorghum grain should be used in lamb-fattening rations where it can be grown more successfully or purchased for less per pound than corn. Since lambs utilize threshed sorghum grain with little waste in the form of undigested grain, experiments have indicated that the slight extra gain from ground sorghum grain may not pay the cost of grinding unless the grain is fed with the roughage.

In an experiment at the Garden City branch of the Kansas Agricultural Experiment Station, Menzies and Erhart (32) compared different roughages for fattening lambs in the feedlot. Sorghum stover, sorghum silage with alfalfa hay, and wheat silage with alfalfa hay were the roughages fed to lambs purchased in New Mexico. They were primarily of white face breeding with a small number of black face crossbreds.

Sorghum silage and alfalfa hay produced the largest and most economical gains. Lambs fed sorghum stover and cottonseed meal instead of sorghum silage and alfalfa hay gained 0.06 pound per lamb per day less than the more efficient lambs. Wheat silage was not eaten as readily as sorghum silage and therefore produced slower, more expensive gains.

In a summary of data from nine experiment stations reporting on feeding pelleted feeds to lambs, Esplin et al. (20) reported that pelleting resulted in a higher daily gain and increased feed efficiency. Three feedlot tests with individual and group feeding were used to compare the relative value of a ration consisting of 47.5 per cent ground corn, 47.5 per cent ground alfalfa hay, and 5 per cent molasses fed in pelleted and non-pelleted forms. With equal consumption of feed, there was little difference in gains and feed efficiency. In the groups self-fed, lambs fed pellets consumed larger amounts of

feed with corresponding larger gains, slightly increased feed efficiency, and improved dressing percentage and carcass grades.

Long et al. (29) conducted a digestibility experiment in which twelve wether lambs were individually fed the same ration in three different physical forms, i. e., natural (long hay and whole grain), ground, and ground and pelleted. The ration was composed of prairie hay, alfalfa hay, corn, cottonseed meal, and molasses. Grinding the whole ration lowered its digestibility. Pelleting the ground ration restored its digestibility to approximately the same level as observed with the ration in the natural state. The average apparent digestion coefficients for organic matter, crude protein, and crude fiber were significantly higher for the pelleted ration than for the ground ration.

Cate et al. (14) studied the effect of pelleting rations of varied quality on feed utilization by lambs. Three different rations were fed to 307 grade feeder lambs in pellet and meal form. The rations fed were alfalfa meal and ground yellow shelled corn; timothy meal, ground yellow shelled corn, soybean oil meal, and molasses which had been calculated to be approximately equal in total digestible nutrients and crude protein to the first ration; and timothy meal and ground yellow shelled corn. Roughage composed 60 per cent of the ration for the first week, 50 per cent for the next three weeks, and 40 per cent for the last eight weeks.

Pelleting significantly increased average daily gains on the two rations using timothy meal as the roughage; no significant increase was shown for pelleting the ration using alfalfa meal as the roughage. Pelleting increased feed consumption on the rations containing timothy meal. Feed required per 100 pounds gain was lower for all rations fed in the pelleted form. The greatest advantage occurred on the lowest quality ration. A greater proportion

of lambs fed pellets reached market at 56 days than lambs fed the same ration in meal form. Higher carcass grades were obtained by pelleting rations containing timothy meal.

This trial indicated that pelleting alfalfa meal and corn was of slight value, hardly enough to warrant the cost of pelleting. Pelleting of rations containing timothy meal greatly increased economy as well as rate of gain. Lambs receiving timothy meal in the pelleted rations outgained the control lots receiving alfalfa as the roughage, indicating that lambs will make satisfactory gains on low quality roughage in self-fed rations, if their daily feed consumption is adequate.

Hartman et al. (22) compared the effect of pelleting and the concentrate to roughage ratio on the performance and carcass quality of fattening lambs. A high concentrate ration consisting of 71 per cent concentrates and 29 per cent roughage, and a high roughage ration consisting of 41 per cent concentrates and 59 per cent roughage, were self-fed either as a pellet or in the meal form.

Lambs fed the high concentrate ration required 12 percent less feed per 100 pounds gain and yielded 1.15 per cent more than the lambs fed the high roughage ration. Pelleting the high roughage ration increased gains by 15 per cent, while pelleting the high concentrate ration depressed gains by 14 per cent. Feed efficiency of either of the rations was not significantly affected by pelleting. Pelleting increased the feed cost per 100 pounds gain by $1.53 and $1.88, respectively, for the high concentrate ration and the high roughage ration.

Weir et al. (45) fed lambs a ration of chopped or pelleted alfalfa, chopped alfalfa plus 30 per cent ground barley, or pelleted alfalfa plus 30 per cent ground barley. Forty lambs were used with the average initial weight

for each lamb being between 66.5 and 66.9 pounds. Average daily gain for the four different lots showed that the pelleted ration resulted in highly significant gains. Addition of barley did not significantly increase gains. Efficiency of feed utilization was increased by pelleting as well as by the addition of barley to the ration. Pelleting of alfalfa alone produced excellent gains, good feed conversion, and satisfactory carcasses, whereas lambs fed chopped alfalfa failed to reach a satisfactory slaughter grade. The incorporation of 30 per cent barley in the pelleted ration did not increase the daily gain or the daily feed intake, but did result in an increase in feed efficiency.

A digestion trial was used to study the alfalfa in chopped and pelleted form with and without added barley. Protein digestibility showed little difference. Fiber digestibility was lower for the pelleted ration when compared with the chopped rations, particularly when barley was included in the ration. Pelleting did not affect the total digestible nutrient content of the rations.

In studies conducted by Meyer et al. (33), results indicated that increased gains due to feeding finely-ground, pelleted alfalfa hay compared to chopped alfalfa hay are due to an increased feed intake. A faster passage of ingesta from the reticulo-rumen seemed to be responsible for this increased feed intake. This in turn was due to a faster rate of holocellulose digestion by the rumen microorganisms. Nitrogen digestibility was higher in lambs fed pelleted hay.

Menzies et al. (31) reported on three years of experiments in which lambs were fed rations varying in the ratio of roughage to concentrate in both pelleted and non-pelleted forms. Lambs on pelleted rations received 0.4 pound of chopped alfalfa hay per head per day. Lambs fed pelleted rations had consistently gained faster and more efficiently than those fed similar non-pelleted rations. Lambs fed pellets containing field-cured alfalfa hay produced slightly

faster gains and made more efficient gains than lambs fed pellets containing dehydrated alfalfa hay. The cost of dehydrating the alfalfa hay resulted in the feed cost per 100 pounds gain being over four dollars higher than the feed cost for the lambs that received the sun-cured alfalfa hay in the pellet.

Slightly larger and cheaper gains were produced by pellets containing 60 per cent roughage and 40 per cent corn than by pellets containing 50 per cent each of roughage and corn. In the non-pelleted form the ration of 55 per cent roughage and 45 per cent corn has proved more efficient as well as more economical than a non-pelleted ration of 65 per cent roughage and 35 per cent corn. There was little difference in carcass grades of the lambs fed the different rations.

Later work by Mensies et al. (30) sought to determine the optimum ratio of grain to roughage in pelleted rations. The rations fed were as follows: lot 1, changing ratio which started with a 20 per cent sorghum grain and 80 per cent alfalfa hay pellet for three weeks, then a 30 per cent grain and 70 per cent hay pellet for the next three weeks, and finished on a 40 per cent grain and 60 per cent hay pellet; lot 2, 20 per cent grain and 80 per cent hay pellet; lot 3, 30 per cent grain and 70 per cent hay pellet; lot 4, 40 per cent grain and 60 per cent hay pellet; lot 5, 40 per cent grain and 60 per cent hay pellet; and lot 6, 50 per cent grain and 50 per cent hay pellet. All lambs except those in lot 5 were fed 0.25 pound of chopped alfalfa hay per lamb per day. The pelleted rations were self-fed from the start of the test.

Lambs in all lots made good gains, averaging 0.610 to 0.737 pound per day. The lambs in lot 3 on the 30:70 pellet made faster, more efficient, and cheaper gains than lambs in the other lots. There was little difference in the carcass grades of the lambs fed the different rations.

Swine

Aubel (6) conducted an experiment in which shelled corn, whole sorghum grain, and ground sorghum grain were fed to fattening pigs. Pigs being fattened on ground sorghum grain made twelve per cent greater average daily gains, while pigs on whole sorghum grain produced eight per cent greater gains than pigs fed shelled corn. Consumption of sorghum grain was higher than corn. Pigs receiving sorghum grain in either form required less protein supplement and more grain per 100 pounds gain.

Another test by Aubel (7) compared open-pollinated and hybrid sorghum grain when self-fed either whole or rolled with shelled corn in pig fattening rations on dry lot. A mixed protein supplement was also self-fed. Pigs receiving the open-pollinated sorghum grain made the largest daily gains, 1.36 pounds per day for the whole grain and 1.37 pounds per day for the rolled grain. Pigs on the hybrid sorghum grain gained 1.19 pounds per day when the grain was fed rolled, and 1.15 pounds per day when fed whole. Pigs on shelled corn gained 1.14 pounds per day. All the pigs fed sorghum grain required fewer pounds of feed to produce 100 pounds of gain than did the pigs fed corn.

The value of shelled corn and hybrid grain sorghums prepared for feeding by different milling processes was studied by Aubel (8). Pigs were self-fed a mixed protein supplement and the following grains: whole hybrid sorghum grain, steam rolled hybrid sorghum grain, steam rolled hybrid sorghum grain with five per cent molasses, steamed hybrid sorghum grain with rolling or crimping delayed four hours, and shelled corn.

Pigs receiving steam rolled hybrid sorghum grain with five per cent molasses ate the most feed per day and made the largest gains, but were not as efficient in feed conversion. Pigs fed corn were the most efficient in feed

conversion. Whole hybrid sorghum grain when fed to pigs resulted in as rapid daily gains as in pigs fed corn, but feed conversion was not as efficient.

Peo and Hudman (37) conducted an experiment in which 224 pigs were used to compare corn with sorghum grain for growing-finishing swine. The corn used in this trial contained either 8.5 per cent protein or 11 per cent protein. Although the greatest average daily gain was made by pigs fed the 8.5 per cent protein corn, the difference between those fed corn and certain of the sorghum grains was not significant. In general, it required approximately 0.2 to 0.7 pound more feed to produce a pound of gain with sorghum grains than with corn.

When corn and sorghum grain were fed alone or in combination at different proportions, the greatest average daily gains were made by the pigs fed a ration composed of one-third corn and two-thirds sorghum grain for the grain portion. The lowest gains were made by those pigs being fed an all sorghum grain ration of 14 per cent protein. Gains on this ration increased as the level of protein was increased from 14 to 16 per cent, but were still significantly less than the gains made on a combination of one-third corn and two-thirds sorghum grain. Pigs fed an all-corn ration required the least feed per pound of gain; but, only 0.05 pound more feed per pound gain was required by pigs fed the one-third corn and two-thirds sorghum grain ration.

Loeffel (28) reported that whole sorghum grain appeared to be more palatable than shelled corn in eleven trials with fattening pigs. Pigs fed sorghum grain and a protein supplement made slightly larger gains than those fed shelled corn and the same supplement. The average efficiency of sorghum grain was 89 per cent that of corn. There was no appreciable difference in dressing yield or carcass quality between pigs fed corn and sorghum grain.

In five trials whole sorghum grain proved slightly more palatable than the same grain coarsely ground. No difference in rate of gain between the two

groups was noted. Coarsely ground sorghum grain proved to be two per cent more efficient than the whole sorghum grain on the basis of the amount of feed required to produce 100 pounds of pork. Finely ground sorghum grain proved less palatable and the pigs made smaller gains than with coarsely ground sorghum grain.

Aubel (5) studied the value of free-choice feeding of shelled corn and a mixed protein supplement with feeding pigs a completely mixed ration in pellet form. The pellets were made after grinding the corn and mixing it with the same supplement at the ratio of three and one-half parts corn to one part supplement. This pellet was fed from 50 to 75 pounds. It contained 19.06 per cent protein. From 75 to 125 pounds the pellet fed was composed of six parts corn to one part protein supplement which contained 16.9 per cent protein. From 125 pounds to market weight, a 14.3 per cent protein pellet composed of nine parts corn to one part supplement was fed.

Pigs on the non-pelleted ration consumed 0.51 pound more feed and gained 0.18 pound more per day than the pigs fed pellets. However, those receiving pellets were more efficient, requiring 30.5 pounds less feed per 100 pounds gain.

Two experiments conducted by Thomas and Flower (44) at Montana State College compared the value of pelleted and non-pelleted rations for fattening swine. In the first experiment pigs fed the pelleted ration required an average of 52 pounds less feed per 100 pounds of gain, gained 0.11 pounds more per day, and reached market weight twelve days sooner than pigs fed the same ration in meal form. In the second experiment there was a significantly greater average daily gain with the pelleted ration. The average amount of feed required per 100 pounds of gain was 345 pounds for the lots fed pellets and 413 pounds for the lots fed meal. Feed cost per 100 pounds gain was

$12.44 for the pigs fed pellets and $11.46 for pigs fed meal. Pigs on the pelleted ration reached market weight fourteen days earlier than pigs on the meal ration.

Dinusson et al. (17) conducted an experiment in which three different rations were self-fed to pigs to compare the value of pulverized barley, ground corn, and pelleted pulverized barley. It was thought that by pulverizing the barley to minimize the effect of fiber, and pelleting to increase the palatability of a dusty mixture, the feeding value might be increased. The control ration consisted of coarsely ground yellow corn, 73 per cent; dehydrated alfalfa, 5 per cent; meat scraps, 5 per cent; soybean oil meal, 16 per cent; salt and mineral supplement, 1 per cent; plus a vitamin A and D supplement. Barley rations contained pulverized barley, 81 per cent; dehydrated alfalfa, 5 per cent; meat scraps, 5 per cent; soybean oil meal, 8 per cent; salt and mineral supplement, 1 per cent; plus a vitamin A and D supplement.

The control pigs gained 1.62 pounds per day and required 4.09 pounds feed per pound gain. Those fed pulverized barley gained 1.57 pounds per day and needed 4.09 pounds feed per pound gain. The lot receiving the pelleted pulverized barley gained 1.79 pounds per day and required 3.39 pounds feed per pound of gain. The cost of pelleting was more than offset by the increased gains and feed efficiency.

Poultry

Payne (36), in citing feeding experiments, stated, "Good quality kafir or milo can replace either white or yellow corn pound for pound in a ration for growing chicks or laying hens when adequately supplemented with other nutrients".

Heywang and Morgan (24) conducted an experiment to compare the value of

yellow corn, yellow milo, and hegari in growing chick rations. Either yellow milo or hegari could be used to replace yellow corn in part or entirely in rations for growing chicks which were not deficient in any way. Feed efficiency was not appreciably changed.

In tests conducted by Hammond (21) at Beltsville, Maryland, corn, milo, and hegari were compared in laying hen rations. In poor quality rations lacking in vitamins and/or high quality protein, corn seemed superior to milo or hegari. No significant differences were found in corn, milo, or hegari as the energy source in a ration, provided that the ration was adequate for high egg production and high hatchability.

Experiments at the Southwest Poultry Experiment Station of the United States Department of Agriculture (34) indicated value in pelleting an all-mash diet for laying hens. Two experiments were conducted in which an all-mash diet was fed in pelleted and non-pelleted forms to two similar groups of White Leghorn pullets. The total egg production per pullet in both experiments was higher in the group fed the pelleted diet. Although feed consumption on the pelleted ration was slightly less, these pullets had a significantly greater live weight than pullets on the non-pelleted all-mash diet at the termination of both experiments. There was no appreciable difference in mortality or in hatchability of eggs.

Morris (35) conducted a feeding trial using seven pens of White Leghorn pullets and four pens of Rhode Island Red pullets. Rations fed were all-mash in pelleted and non-pelleted forms, a conventional 21 per cent protein mash fed in pelleted and non-pelleted forms with grain fed in troughs morning and evening, a 32 per cent protein concentrate fed pelleted and non-pelleted with grain before the pullets at all times, and a variation of mash and grain feeding with pellets fed as a noon lunch.

Results showed little difference in egg production between the various rations. The cost of egg production was slightly higher when pellets were fed. Lots fed pellets had uniformly heavier body weights and better condition through the trial. Feeding pellets as a noon lunch stimulated egg production and kept body weight higher.

Heywang and Morgan (23) studied results of feeding an all-mash diet to growing chicks in pelleted and non-pelleted forms. White Leghorn chicks were used in six experiments in which the different forms of feed were fed to two similar groups of chicks. Cockerels were removed from the groups when they were twelve weeks old, but the experiments were continued until the pullets were 22 weeks old. Data on the live weight and age of the pullets on their first day of egg production were obtained.

In all six experiments the average live weight of the twelve-week-old cockerels receiving the pelleted all-mash diet was significantly greater than that of cockerels receiving the non-pelleted all-mash diet. Cannibalism was not observed, but feather picking occurred in two of the groups receiving pellets. When placed in a pen with a larger area, feather picking stopped.

In five of the six experiments, the average weight of the pullets at 12 and 22 weeks was significantly greater in the lots fed pellets. On the first day of egg production in each experiment, the average live weight of the pullets receiving the pelleted all-mash diet was greater than the live weight of the pullets on the non-pelleted diet. The differences were statistically significant in two of the experiments. Pullets on the pelleted diet average six days younger on the first day of egg production. Average feed consumption and the efficiency of feed utilization were greater with the lots fed pellets.

In a series of trials by Kley and Hoffmann (19), lots of birds were fed fine, medium, and coarsely ground diets; the diet was also fed in pelleted

form. Feed particle size had no effect on moisture content of the droppings, water or feed consumption, or weight gains. Approximately one-fourth gram of feed per bird per day was recovered from the drinking water of birds fed finely ground feed, while a negligible amount was recovered when birds were fed pellets. Since this wastage would amount to an annual loss of 20 pounds of feed per 100 birds, the difference was highly significant statistically.

Bearse et al. (11) made comparisons of growth rate and feed efficiency of light and heavy breed chickens fed rations of different fiber levels in mash and pellet form. Pelleting rations containing eight, thirteen, and eighteen per cent fiber increased growth rate in Leghorn pullets. Differences between mash and pellets became more marked as fiber level increased.

Heavy breed chickens were used to compare a 66 per cent corn ration with rations containing 35 per cent corn and 35 per cent barley, and 39 per cent corn and 35 per cent wheat mixed feed. At approximately ten and one-half weeks of age, the average weight was 0.16 pound greater for the pelleted corn ration than for the same mash. Pelleting the corn-barley ration increased the average weight by 0.28 pound. Similar treatment of the corn-wheat mixed feed ration increased average weight by 0.33 pound.

Chickens fed the pelleted higher fiber rations, except the eighteen per cent level, were heavier than those fed the high corn ration in mash form. Pelleting the various rations improved their efficiency for growth. This improvement was progressively greater as the fiber level of the ration increased.

Pellets, mash, and granules were compared by Stewart and Upp (43) in their effect on growth and feed efficiency in broiler rations. In three trials involving 900 White Plymouth Rock chicks fed for twelve weeks, the form of feed did not greatly affect the rate of growth or the feed efficiency. No one form of feed produced especially superior dressed birds as compared to the

other forms. Cannibalism or feather picking was not a problem of consequence in these trials, although the tendency toward it was greater in the lots fed pellets and granules.

Granular feed produced significantly better growth in trial three than either pellets or mash, but no one form of feed showed statistically significant superiority in the first two trials. High mortality in the first two trials may have affected the results.

Lanson and Smyth (26) conducted an experiment in which mash was fed to six pens of 400 White Plymouth Rock male sexed chicks to four weeks of age. Then two pens each were fed on mash, pellets, or mash with an afternoon feeding of pellets sufficient to replace one-third of the daily mash consumption.

Broilers receiving pellets weighed 3.79 pounds at the end of ten weeks. Those fed pellets and mash weighed 3.70 pounds, while those fed mash weighed 3.49 pounds. Feed conversion was also superior in the broilers fed pellets.

Observations indicated less time was spent eating with the broilers fed pellets, allowing more inactive time. This saving of energy may account for the superior weight and feed conversion. Another theory advanced is that perhaps the increased density of the feed in pelleted form allowed the broilers to better meet their increased nutritive requirements, especially at the end of the feeding period. Weighings indicate that the increased weight of the broilers fed pellets became more apparent during the last two weeks of growth.

Lindblad et al. (27) conducted a series of experiments to compare barley with corn and wheat in broiler rations fed in both pellet and mash form. Substituting barley for equal parts of corn and wheat in a practical broiler ration up to 50 per cent of the total ration resulted in a reduction in weight of males where the feed was fed in mash form. In contrast, when the feed was fed in pellet form, 50 per cent barley in the ration had no depressing effect

on the weight of males but a slight reduction in female weights was observed in one experiment. Carcass grading results indicated decreased fleshing and finish with 50 per cent barley rations in mash form. Pelleting the rations largely overcame the adverse influence of the high barley ration.

Feed efficiency was reduced with rations containing 50 per cent barley, but in all cases pelleting improved the efficiency of feed utilization. Feed consumption data indicated that the improved performance on pelleted rations was not due to increased feed consumption. Males responded to pelleting to a greater degree than did the females.

Allred et al. (2) conducted a series of experiments to study the effect of pelleted rations on growth and feed efficiency of chicks and poults, and to study the relationships of pelleting to the protein and fat content of the ration. Pelleting the rations improved growth rate and feed efficiency of both species. A growth response to pelleting was obtained even when the pellets were ground to a particle size and density similar to the original mash. The pelleting effect of increased growth and efficiency was obtained whether or not animal fat was added to the ration. Rations containing protein levels varying from 20 to 24 per cent gave the same response to pelleting. The authors concluded that a large part of the increased growth and feed efficiency effect obtained by pelleting may be due to some chemical change, possibly the inactivation of a growth inhibitor in the ration.

Later work reported by Allred et al. (1) was designed to study the effect of pelleting individual ingredients and complete rations on the growth and feed efficiency of chicks. Evidence was presented that both a physical and non-physical change occurred during the pelleting process, each of which significantly increased growth and feed efficiency beyond that of chicks fed non-pelleted rations. When individual ingredients were pelleted, reground and

incorporated into an otherwise non-pelleted ration, the only ingredients affected were corn and rye as measured by chick performance. Pelleting of pearled barley did not affect growth.

Corn was subjected to various heat and moisture treatments in an attempt to simulate pelleting under laboratory conditions. Steaming, water-soaking, or autoclaving corn did not affect chick growth or feed efficiency. Pearled barley and rye were water-soaked and autoclaved without significantly increasing chick growth. Water-soaked rye caused an increased in weight of chicks that approached significance. Feed efficiency was significantly improved by water-soaking both pearled barley and rye.

Arscott et al. (3) conducted two experiments to test the hypothesis that the pelleting response noted on high barley or corn feeds may be due to a chemical change in the feed resulting from pelleting. Regrinding barley or corn pellets resulted in no improvement in growth or feed conversion when compared with their non-pelleted controls. In every instance, however, pelleting effected a marked improvement in growth.

In the first experiment barley consisted of 61.5 per cent of the ration. In the second experiment barley consisted of 57.8 per cent of the ration with 3 per cent added fat and 0.7 per cent additional soybean oil meal added at the expense of the barley to keep the protein level constant. Corn composed 61.5 per cent of the ration in experiment two.

Chicks in both experiments were fed for eight weeks. Growth and feed conversion in the chicks fed the barley pellet with three per cent added fat were comparable to chicks fed the corn mash. Pelleting corn mash resulted in a significant growth response.

Later work by Arscott et al. (4) consisted of floor-pen trials of eight to nine weeks involving 7076 broilers. These trials were conducted to

determine the amount of barley that will efficiently replace the ground corn component in high-energy rations containing varying levels of stabilized animal fat. Performance efficiency data show that barley may replace one-half and three-fourths of the ground corn in an all-mash ration with results at least comparable to an all-corn ration containing no added fat, provided such rations contain three and six per cent fat, respectively. The addition of three to six per cent fat to all-corn rations resulted in further improvement in performance efficiency. All-barley mash rations produced inferior results both from the standpoint of growth and feed efficiency in the presence or absence of fat.

Pelleted rations containing all-corn, one-half barley and one-half corn, or all-barley in the presence or absence of three per cent fat effected a marked improvement in performance efficiency. This improvement was particularly noticeable with lots fed all-barley pellets with zero and three per cent fat, the latter of which compared favorably to the all-corn mash with no fat.

In studies conducted by Ziegenhagen et al. (47), rate of growth in turkey poults during the first eight weeks was significantly increased through the feeding of pellets or granular type feed. Poults fed mash had the lowest feed efficiency partly due to the amount of feed wasted. Cannibalism in this experiment occurred only in the lot fed granular feed; however, in previous trials cannibalism was noted in lots fed granules and pellets. In one lot receiving mash and pellets free choice, the mash was eaten more readily for the first two weeks after which the pellets were favored more strongly by the poults.

Slinger et al. (42) fed groups of Broad Breasted Bronze turkeys mashes containing ten, fifteen, and twenty per cent of a mixture of equal parts of dehydrated alfalfa and dehydrated cereal grass in both non-pelleted and

pelleted forms. The results of the experiment indicated that while slightly better growth rate was obtained from the lower levels of green feed, even the 20 per cent level gave satisfactory results. Much greater differences were found between the pelleted and non-pelleted mashes, however, than between the levels of the dehydrated products. The weights of all the groups receiving pellets were greater than those of any group receiving mash. The increased weights were significant in most cases. More advantage appears to be gained by pelleting mashes containing 15 and 20 per cent of dehydrated products than mash containing ten per cent. Based on total feed consumption, efficiency of gain tended to be increased by pelleting, but the differences were not marked. Poults fed pellets began feather picking at a relatively early age.

Dymsza et al. (18) conducted an experiment in which diets containing five, ten, or fifteen per cent fiber were fed to twelve groups of 20 sexed day-old White Holland poults in the form of mash or crumbles. Diets in the form of crumbles gave weight increases of 42 to 615 grams over weight obtained with mash at eight weeks of age. Only in the case of females on the five per cent fiber diet was the difference between weights on mash and crumbles not highly significant.

EXPERIMENT I - WINTERING RATIONS

Experimental Procedure

Forty head of good to choice quality Hereford steer calves from the same herd were used in this experiment. Average weight at the start of the experiment was approximately 420 pounds. These steers had been previously castrated and dehorned at the ranch where they were purchased near Alpine, Texas. Each steer was branded after arrival at the Kansas State University Experimental Pens so as to facilitate identification. In preparation for the wintering

phase of the feeding trial, the steers were fed gradually increasing amounts of Atlas sorghum silage and alfalfa hay.

The steers were divided as equally as possible into four groups of ten each on the basis of weight, size, and conformation. Groups of steers were then allotted to the various rations by random selection. Steers were weighed on two consecutive days at the start of the wintering phase of the test on December 2, 1958. Table 1 shows the average daily ration fed per steer during the 100-day wintering period.

Table 1. Average daily feed consumption per head during the wintering period.

Lot number	1	2	3	4
Alfalfa hay	4.0	4.0	4.0	4.0
Dehydrated grain sorghum pellets	7.65	—	—	—
Grain sorghum silage	—	20.55	—	—
Atlas sorghum silage	—	—	14.10	12.65
Cracked sorghum grain	—	—	4.0	—
Pelleted sorghum grain	—	—	—	4.0
Soybean oil meal	0.5	0.5	0.5	0.5
Salt	0.035	0.018	0.052	0.016
Bone meal-salt mixture	0.085	0.061	0.061	0.039

The entire plant of combine-type grain sorghum from the same field on the Kansas Agricultural Experiment Station Farm was used to make the grain sorghum silage and the dehydrated grain sorghum pellets. Grain yield was estimated to be 45 bushels per acre. It produced approximately six tons of silage or two and one-half tons of dehydrated pellets per acre. The silage was drier than most good quality silage, but the steers ate it readily after becoming accustomed to the change from Atlas sorghum silage.

Atlas sorghum silage, also grown on the Kansas Agricultural Experiment Station Farm, was of good quality and contained a lot of grain. It proved to

be very palatable to the steers.

The alfalfa hay used in this experiment was grown locally.

Sorghum grain was purchased in truckload lots from a local elevator as needed, then divided into equal portions which were prepared in cracked and pelleted forms by the Milling Department at Kansas State University. The sorghum grain was of good quality and very clean.

Chemical analyses of the feeds used in the experiment are shown in Table 2. Samples were obtained during wintering and fattening phases of the experiment, and duplicate samples were analyzed for each feed.

Table 2. Chemical analyses of feeds used in the experiment.

Feed ingredient	Percentage					
	Dry Matter	Crude Protein	Crude Fiber	Ether Extract	Ash	N-free Extract
Dehydrated grain sorghum pellets (W)[1]	92.29	9.50	15.88	2.02	7.76	57.13
Dehydrated grain sorghum pellets (F)[2]	91.46	11.06	14.07	2.15	6.46	57.72
Grain sorghum silage (W)	39.99	4.07	6.27	1.10	3.62	24.93
Grain sorghum silage (F)	33.36	3.81	5.84	1.06	3.22	19.43
Atlas sorghum silage (W)	28.35	1.81	7.83	0.75	2.13	15.83
Atlas sorghum silage (F)	28.79	2.19	7.06	1.02	2.15	16.37
Cracked sorghum grain (W)	88.87	11.50	2.09	2.82	1.63	70.83
Cracked sorghum grain (F)	88.42	9.06	2.29	2.56	1.54	72.97
Pelleted sorghum grain (W)	89.04	11.81	2.01	1.75	2.07	71.40
Pelleted sorghum grain (F)	89.07	9.31	1.68	2.39	1.58	74.11
Alfalfa hay (W, F)	91.03	14.13	29.89	1.23	8.58	37.20
Soybean oil meal (W, F)	91.52	50.25	2.79	0.72	5.93	31.83
Dehydrated alfalfa pellets (F)	92.38	14.63	27.67	2.92	9.12	38.04

1. Sample obtained during wintering phase of the experiment.
2. Sample obtained during fattening phase of the experiment.

Salt and a mineral mixture of two parts steamed bonemeal and one part salt were available in separate sheltered boxes to the steers throughout the experiment. Drinking water was supplied by automatic electrically-heated

water fountains.

The lots of steers were fed once daily in the morning except for the alfalfa hay which was fed in the afternoon. Silage was spread in the feed bunks and the concentrate portion of the ration scattered over the silage. Alfalfa hay was fed in separate hay racks. Lot 1, receiving the dehydrated grain sorghum pellets, had the soybean oil meal scattered over the pellets.

Steers were individually weighed every 28 days throughout the wintering phase, and on two consecutive days at the completion of the 100-day wintering trial on March 12, 1959. Records were kept of the daily feed consumption of each lot. Upon termination of the wintering period, calculations were made to determine the average daily gain per steer, daily feed consumption per steer, amount of feed needed per 100 pounds gain, and the cost per 100 pounds gain.

Results and Discussion

The purpose of this phase of the experiment was to compare the value of grain sorghum silage with dehydrated grain sorghum pellets, and to compare the value of cracked sorghum grain with pelleted sorghum grain in wintering rations for beef cattle. Indirect comparisons were made between each of the different rations fed. A summary of the complete results of the wintering phase of this study is shown in Table 3.

Feed cost per 100 pounds gain was calculated by using the current prices as shown in Table 4. The value of the dehydrated grain sorghum pellets was calculated by considering the actual cost of harvesting, dehydrating, grinding, and pelleting, as well as the value of the sorghum grain had it been harvested as mature grain. Total processing charges were $30.00 per ton. The cost of the grain sorghum silage is likewise higher than that of Atlas sorghum silage because of the yield of sorghum grain that would have been harvested had it

Table 3. Comparative results with (1) dehydrated grain sorghum pellets and grain sorghum silage, and (2) cracked sorghum grain and finely ground pelleted sorghum grain in beef steer wintering rations.

Lot number	1	2	3	4
Av. initial weight, lbs.	415.5	416.0	418.0	424.0
Av. final weight, lbs.	550.5	552.0	568.5	586.5
Av. daily gain per steer, lbs.	1.35	1.36	1.51	1.63
Av. daily ration, lbs.				
Alfalfa hay	4.0	4.0	4.0	4.0
Dehydrated grain sorghum pellets	7.65	—	—	—
Grain sorghum silage	—	20.55	—	—
Atlas sorghum silage	—	—	14.1	12.65
Cracked sorghum grain	—	—	4.0	—
Pelleted sorghum grain	—	—	—	4.0
Soybean oil meal	0.5	0.5	0.5	0.5
Salt	0.035	0.018	0.052	0.016
Bonemeal-salt mixture	0.085	0.061	0.061	0.039
Feed per 100 pounds gain, lbs.				
Alfalfa hay	296.3	294.1	264.9	245.3
Dehydrated grain sorghum pellets	566.7	—	—	—
Grain sorghum silage	—	1511	—	—
Atlas sorghum silage	—	—	933.8	776.1
Cracked sorghum grain	—	—	264.9	—
Pelleted sorghum grain	—	—	—	245.3
Soybean oil meal	37.0	36.8	33.1	30.7
Salt	2.6	1.3	3.4	1.0
Bonemeal-salt mixture	6.3	4.5	4.0	2.4
Feed cost per 100 lbs. gain	$17.59	$10.86	$10.89	$10.16

not been harvested as silage.

Steers receiving dehydrated grain sorghum pellets made virtually the same gains as the steers receiving grain sorghum silage. Both groups were nearly equal in feed efficiency. An attempt was made to keep the dry matter intake of the two groups equal. No digestive disturbances or other troubles were observed from feeding dehydrated grain sorghum pellets. However, the added cost of dehydrating and pelleting the grain sorghum plant resulted in the feed cost per 100 pounds gain being considerably higher for the steers fed the

Table 4. Feed prices used in wintering and fattening steer rations.

Feed ingredient	Unit of measurement	Price
Alfalfa hay	Ton	$11.00
Dehydrated grain sorghum pellets	Ton	50.00
Grain sorghum silage	Ton	10.00
Atlas sorghum silage	Ton	5.00
Cracked sorghum grain	Cwt.	2.10
Pelleted sorghum grain	Cwt.	2.25
Soybean oil meal	Ton	80.00
Dehydrated alfalfa pellets	Ton	40.00
Salt	Cwt.	1.10
Bonemeal-salt mixture	Cwt.	4.47

dehydrated grain sorghum pellets.

The rate of gain and feed efficiency of the steers fed grain sorghum silage was quite satisfactory, although the rate of gain was lower than either group of steers receiving Atlas sorghum silage and a form of sorghum grain. This ration proved practical from an economic standpoint, being just slightly more economical in producing 100 pounds gain than the ration containing cracked sorghum grain. Data obtained in this experiment show that harvesting a grain sorghum crop as silage may be quite feasible.

The steers fed cracked sorghum grain and Atlas sorghum silage made slightly smaller daily gains than the steers fed pelleted sorghum grain and Atlas sorghum silage. These steers also consumed more feed per 100 pounds gain than the steers receiving pelleted sorghum grain and Atlas sorghum silage. Cost of producing 100 pounds of gain was higher when cracked sorghum grain was fed than when pelleted sorghum grain was fed. Rate of gain for the first 56 days of the wintering period was higher for the steers fed cracked sorghum grain than for steers fed pelleted sorghum grain; however, the rate of gain for these steers had fallen below the rate of gain for the steers fed pelleted sorghum

grain by 84 days and was still as a lower rate at the termination of the wintering phase of the experiment.

Steers receiving pelleted sorghum grain made the greatest average daily gains during the wintering period. They consumed less feed in producing 100 pounds of gain than the steers receiving cracked sorghum grain, and the cost of producing 100 pounds of gain was the lowest in the experiment. For some unknown reason, this group of steers went off feed for a few days early in the wintering period. An equal amount of cracked sorghum grain was substituted for one week, after which they resumed eating the pelleted sorghum grain at the desired level. The additional cost of pelleting the sorghum grain was more than offset by the increased rate of gain and increased feed utilization.

Several steers in each lot had pinkeye early in the wintering period. A sulfa powder was dusted directly on the infected eye and the steers recovered promptly with one to three treatments, depending upon the severity of the infection. Since the degree of infection and the incidence of infection were nearly equal in all lots, it was assumed that pinkeye had little effect upon the results of the wintering phase of the experiment.

In the lot receiving dehydrated grain sorghum pellets, one steer died of an unknown cause twelve days after the start of the experiment. Another steer of similar weight from the same herd was used as a replacement.

Summary

Forty Hereford steer calves were randomly divided into four lots of ten steers each and fed wintering rations containing dehydrated grain sorghum pellets, grain sorghum silage, Atlas sorghum silage with cracked sorghum grain, or Atlas sorghum silage with pelleted sorghum grain. In addition, each lot received alfalfa hay and soybean oil meal in the ration, with salt and a bonemeal-

salt mixture fed free choice. The wintering period was of 100 days duration.

Feed efficiency and rate of gain obtained with the steers receiving dehydrated grain sorghum pellets and grain sorghum silage were nearly equal. However, the added cost of dehydrating and pelleting the grain sorghum plant resulted in a much higher feed cost per 100 pounds of gain for the steers receiving the dehydrated grain sorghum pellets. No digestive disturbances or other trouble were encountered during the feeding period. In comparison with the steers receiving Atlas sorghum silage and a form of sorghum grain, it was concluded that harvesting a grain sorghum crop as silage may be economically sound since the cost of producing 100 pounds of gain was nearly equal for the steers fed grain sorghum silage and those fed Atlas sorghum silage and cracked sorghum grain.

Steers fed the ration containing pelleted sorghum grain made a greater average daily gain, consumed less feed per 100 pounds of gain, and produced 100 pounds of gain more economically than the steers fed the ration containing cracked sorghum grain. The steers receiving pelleted sorghum grain had the highest and most economical gains during the wintering period.

EXPERIMENT II - FATTENING RATIONS

Experimental Procedure

Forty head of Hereford feeder steers used in Experiment I were used to compare fattening rations containing dehydrated grain sorghum pellets, grain sorghum silage, Atlas sorghum silage with cracked sorghum grain, or Atlas sorghum silage with pelleted sorghum grain. Soybean oil meal and dehydrated alfalfa pellets were fed as a part of the daily ration for all lots with salt and a bonemeal-salt mixture fed free choice. Steers in lots 3 and 4 receiving

Atlas sorghum silage and a form of sorghum grain also received alfalfa hay. Table 5 shows the average daily ration fed per steer during the 112-day fattening period.

Table 5. Average daily feed consumption per head during the fattening period.

Lot number	1	2	3	4
Alfalfa hay	—	—	5.5	2.4
Dehydrated grain sorghum pellets	17.4	—	—	—
Grain sorghum silage	—	38.1	—	—
Atlas sorghum silage	—	—	7.7	7.7
Cracked sorghum grain	—	—	11.8	—
Pelleted sorghum grain	—	—	—	11.8
Soybean oil meal	1.0	1.0	0.5	0.5
Dehydrated alfalfa pellets	1.0	1.0	0.5	0.5
Salt	0.046	0.063	0.078	0.021
Bonemeal-salt mixture	0.050	0.052	0.035	0.028

Steers receiving the rations containing dehydrated grain sorghum pellets and grain sorghum silage had the alfalfa hay removed from their rations at the start of the fattening period. Dehydrated alfalfa pellets were fed to satisfy carotene requirements.

The steers were brought to full feed by gradually increasing the amounts of feed placed in the feed bunk at each feeding for lots 1 and 2. The grain was increased in lots 3 and 4. The method of feeding and information about the different feeds used have been discussed under the experimental procedure of Experiment I.

Steers were individually weighed on two consecutive days when the fattening phase of the test was started on March 12, 1959, and every 28 days thereafter. For purposes of this thesis, the test was terminated after 112 days on July 2, 1959, with individual weights being recorded on two consecutive days.

Calculations were made to determine the average daily gain per steer, daily feed consumption per steer, amount of feed needed per 100 pounds gain, and the cost per 100 pounds gain at the close of the fattening period.

Results and Discussion

The purpose of this phase of the experiment was to compare the value of grain sorghum silage with dehydrated grain sorghum pellets, and to compare the value of cracked sorghum grain with pelleted sorghum grain in fattening rations for beef cattle. Indirect comparisons were made between each of the different rations fed. A summary of the complete results of the fattening phase of this study is shown in Table 6.

The steers receiving the ration containing dehydrated grain sorghum pellets made higher average daily gains than those receiving the ration containing grain sorghum silage. These steers also showed greater feed efficiency than the steers fed grain sorghum silage. However, the added cost of dehydrating and pelleting resulted in a considerably higher cost per 100 pounds of gain for the steers receiving dehydrated grain sorghum pellets when compared with the steers receiving grain sorghum silage.

Steers fed dehydrated grain sorghum pellets received no coarse roughage in their ration, but showed no digestive disturbances. No regurgitation and chewing of the cud as in normal rumination was observed in this group of steers. A moderate craving developed in which the steers chewed to some extent upon the boards forming the fence around their pen. They had also licked away dirt on the outside of the pen where some grass and weeds had started growth. All grass and weeds within reach were devoured.

The rate of gain at both the 56th and 84th days corresponded closely for the steers fed the rations containing dehydrated grain sorghum pellets and

Table 6. Comparative results with (1) dehydrated grain sorghum pellets and grain sorghum silage, and (2) cracked sorghum grain and finely ground pelleted sorghum grain in beef steer fattening rations.

Lot number	1	2	3	4
Av. initial weight, lbs.	550.5	552.0	568.5	586.5
Av. final weight, lbs.	782.0	739.5	822.5	854.0
Av. daily gain per steer, lbs.	2.07	1.67	2.28	2.39
Av. daily ration, lbs.				
Alfalfa hay	—	—	5.5	2.4
Dehydrated grain sorghum pellets	17.4	—	—	—
Grain sorghum silage	—	38.1[1]	—	—
Atlas sorghum silage	—	—	7.7	7.7
Cracked sorghum grain	—	—	11.8	—
Pelleted sorghum grain	—	—	—	11.8
Soybean oil meal	1.0	1.0	0.5	0.5
Dehydrated alfalfa pellets	1.0	1.0	0.5	0.5
Salt	0.046	0.063	0.078	0.021
Bonemeal-salt mixture	0.050	0.052	0.035	0.028
Feed per 100 lbs. gain, lbs.				
Alfalfa hay	—	—	241	100
Dehydrated grain sorghum pellets	841	—	—	—
Grain sorghum silage	—	2281[2]	—	—
Atlas sorghum silage	—	—	338	322
Cracked sorghum grain	—	—	517	—
Pelleted sorghum grain	—	—	—	494
Soybean oil meal	48.3	59.9	21.9	20.9
Dehydrated alfalfa pellets	48.3	59.9	21.9	20.9
Salt	1.9	2.6	3.3	0.9
Bonemeal-salt mixture	2.1	2.2	1.5	1.2
Feed cost per 100 lbs. gain	$24.04	$15.13	$14.45	$13.85

1. Average daily ration for first 92 days only.
2. Average daily ration was used to calculate feed consumed in 112 days.

grain sorghum silage. Weights for two consecutive days were recorded at 92 days for these two groups of steers since the grain sorghum silage was rapidly deteriorating in quality. Consumption of grain sorghum silage was reduced from 45 pounds per head per day to 30 pounds per head per day. Three pounds of cracked sorghum grain per head was fed to these steers to replace the grain normally consumed each day from the silage. At 100 days the supply of grain

sorghum silage was depleted and the steers in this lot were placed on Atlas sorghum silage and cracked sorghum grain.

Another factor which affected the performance of the steers was a severe outbreak of foot rot during extremely hot weather. Nearly equal numbers of steers in lots 1 and 2 and in lots 3 and 4 were affected, but lot 2 seemed to be affected to a greater extent than the other lots. Between 84 and 92 days, these steers which were being fed the ration containing grain sorghum silage averaged losing 0.94 pound per head per day for the eight day period. Two individual steers lost 30 and 35 pounds while only two steers in the group gained weight on the two consecutive days of weighing at 92 days. The steers receiving dehydrated grain sorghum pellets continued to gain at a reduced rate during this period although an equal number had been affected by foot rot.

An organic iodine compound (ethylenediamine dehydriodide) was mixed with the salt in an attempt to reduce the incidence of foot rot. Cases of foot rot were promptly treated by the veterinarians.

The steers receiving the ration containing grain sorghum silage made slightly smaller average daily gains than the steers receiving dehydrated grain sorghum pellets until the trouble from foot rot occurred, after which the average daily gain was considerably smaller. Feed efficiency was also lower for these steers than for the steers fed dehydrated grain sorghum pellets. Feed cost per 100 pounds gain was more economical for the steers receiving grain sorghum silage than for those receiving dehydrated grain sorghum pellets. When compared with the steers receiving Atlas sorghum silage and a form of sorghum grain, the cost of gain was slightly higher for the steers fed grain sorghum silage and much higher for those fed dehydrated grain sorghum pellets.

Steers fed the ration containing cracked sorghum grain made slightly

smaller average daily gains than steers fed the ration containing pelleted sorghum grain. The steers fed cracked sorghum grain consumed more feed per 100 pounds of gain and the cost was greater per 100 pounds of gain than for steers fed pelleted sorghum grain. The consumption of Atlas sorghum silage, soybean oil meal, dehydrated alfalfa pellets, and the different forms of sorghum grain were kept equal throughout the fattening period for these two lots of steers. However, the lot fed the ration containing cracked sorghum grain would have readily consumed more silage and concentrates had it been fed to them. The consumption of alfalfa hay, which was fed free choice, was over twice as great for the steers fed cracked sorghum grain as for the ones fed pelleted sorghum grain.

Steers receiving pelleted sorghum grain in their ration had the highest average daily gains, and produced 100 pounds of gain more economically than any other lot of steers.

Summary

Fattening steer rations containing dehydrated grain sorghum pellets, grain sorghum silage, Atlas sorghum silage with cracked sorghum grain, or Atlas sorghum silage with pelleted sorghum grain were fed to four lots of ten Hereford steers each after completion of the wintering phase of this experiment. Each lot also received soybean oil meal and dehydrated alfalfa pellets in the ration, with salt and a bonemeal-salt mixture fed free choice. Alfalfa hay was fed free choice to the steers receiving the rations containing Atlas sorghum silage and a form of sorghum grain. The fattening period was terminated, for purposes of this thesis, at 112 days.

Feed efficiency and rate of gain obtained with the steers receiving rations containing dehydrated grain sorghum pellets and grain sorghum silage

were nearly equal for the first 84 days of the experiment. Possibly because of many severe cases of foot rot, extremely hot weather, and a poorer quality of silage fed to the steers receiving grain sorghum silage during the last 28 days of the test, the lot receiving dehydrated grain sorghum pellets made higher average daily gains, and consumed less feed to produce 100 pounds of gain. The feed cost per 100 pounds of gain was higher for the steers fed dehydrated grain sorghum pellets because of the high cost of dehydrating and pelleting.

No digestive disturbances in the steers receiving dehydrated grain sorghum pellets were observed during the fattening phase of the experiment. A craving developed in the lot being fed the ration containing dehydrated grain sorghum pellets which resulted in boards on the fence being chewed and dirt around the outside of the pen being licked by the steers.

Steers receiving the ration containing grain sorghum silage had the smallest average daily gain in the experiment.

The steers fed the fattening rations containing Atlas sorghum silage and cracked or pelleted sorghum grain produced higher average daily gains and more economical gains than the other two lots of steers.

The ration containing cracked sorghum grain produced smaller average daily gains than the ration containing pelleted sorghum grain. The steers fed cracked sorghum grain consumed more feed per 100 pounds gain and had a higher feed cost per 100 pounds gain than the steers fed pelleted sorghum grain. This is in agreement with previous work by Pope et al. (38) and Richardson et al. (41).

Steers fed pelleted sorghum grain in the ration made the highest average daily gains, and produced 100 pounds of gain more economically than any other group of steers.

GENERAL SUMMARY

The purpose of this experiment was to determine the comparative value of combine-type grain sorghum harvested and fed as silage or dehydrated pellets, and to determine the comparative value of cracked sorghum grain and pelleted sorghum grain in wintering and fattening rations for beef cattle. Forty good to choice quality Hereford steer calves were randomly divided into four lots of ten each and fed rations containing dehydrated grain sorghum pellets, grain sorghum silage, Atlas sorghum silage with cracked sorghum grain, or Atlas sorghum silage with pelleted sorghum grain. Alfalfa hay and soybean oil meal were fed to each lot as a part of the wintering ration.

Feed efficiency and rate of gain obtained with the steers fed dehydrated grain sorghum pellets and grain sorghum silage were nearly equal during the wintering period. The added cost of dehydrating and pelleting the grain sorghum plant resulted in a much higher feed cost per 100 pounds of gain for the steers fed the dehydrated grain sorghum pellets. Cost of gain for the steers fed grain sorghum silage compared favorably with the cost of gain for steers fed Atlas sorghum silage and cracked sorghum grain during the wintering phase of this experiment.

Steers fed the wintering ration containing pelleted sorghum grain made greater average daily gains, consumed less feed per 100 pounds of gain, and produced 100 pounds of gain more economically than steers fed the wintering ration containing cracked sorghum grain. The steers fed pelleted sorghum grain made the highest and most economical gains obtained during the wintering period.

Soybean oil meal and dehydrated alfalfa pellets were added to the fattening ration for each lot of steers. Alfalfa hay was fed to those steers receiving Atlas sorghum silage and a form of sorghum grain during the fattening

period. No hay was fed to those receiving dehydrated grain sorghum pellets or grain sorghum silage.

For the first 84 days of the fattening phase of the experiment, feed efficiency and rate of gain obtained with the steers fed rations containing dehydrated grain sorghum pellets and grain sorghum silage were nearly equal. During the next eight days of the fattening period, a combination of several severe cases of foot rot, extremely hot weather, and a reduction in the quality and amount of grain sorghum silage available resulted in a loss of weight by the steers being fed grain sorghum silage. At the termination of this test, steers being fed dehydrated grain sorghum pellets had made greater average daily gains and had consumed less feed per 100 pounds of gain during the fattening period than the steers being fed grain sorghum silage. Again, the higher cost of dehydrating and pelleting the grain sorghum plant offset the increased gains and feed efficiency, and resulted in the steers being fed grain sorghum silage producing more economical gains.

The steers fed the fattening rations containing Atlas sorghum silage and cracked or pelleted sorghum grain produced higher average daily gains and more economical gains than the other two lots of steers.

Steers fed the ration containing pelleted sorghum grain made greater average daily gains, consumed less feed per 100 pounds gain, and produced 100 pounds of gain more economically than steers fed the ration containing cracked sorghum grain.

During both wintering and fattening phases of this experiment, steers fed pelleted sorghum grain made the greatest gains and produced these gains more economically than any other group of steers. The steers fed cracked sorghum grain ranked second in amount and economy of gains. Steers fed grain sorghum silage ranked third in cost of gains, but had the lowest gains in the test.

Steers fed dehydrated grain sorghum pellets ranked third in rate of gain, but had the highest cost of gains during the course of the experiment. A summary of the results of this experiment is given in Table 7.

Table 7. A summary of the comparative results with (1) dehydrated grain sorghum pellets and grain sorghum silage, and (2) cracked sorghum grain and finely ground pelleted sorghum grain in beef steer rations.

Lot number	1	2	3	4
Wintering results				
Av. total gain, lbs.	135.0	136.0	150.5	162.5
Av. daily gain, lbs.	1.35	1.36	1.51	1.63
Feed cost per cwt. gain	$17.59	$10.86	$10.89	$10.16
Fattening results				
Av. total gain, lbs.	231.5	187.5	254.0	267.5
Av. daily gain, lbs.	2.07	1.67	2.28	2.39
Feed cost per cwt. gain	$24.04	$15.13	$14.45	$13.85
Summary				
Av. total gain, lbs.	336.5	323.5	404.5	430.0
Av. daily gain, lbs.	1.73	1.53	1.91	2.03
Feed cost per cwt. gain	$21.67	$13.34	$13.12	$12.46

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COMPARATIVE VALUE OF GRAIN SORGHUM SILAGE, DEHYDRATED GRAIN SORGHUM PELLETS, CRACKED SORGHUM GRAIN, AND FINELY GROUND PELLETED SORGHUM GRAIN IN BEEF CATTLE RATIONS

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fattening period, a combination of several severe cases of foot rot, extremely hot weather, and a reduction in the quality and amount of grain sorghum silage available resulted in a loss of weight by the steers being fed grain sorghum silage. At the end of the 112-day fattening period, steers fed dehydrated grain sorghum pellets had made greater average daily gains on less feed than steers fed grain sorghum silage. Feed cost per 100 pounds of gain was lower for steers fed grain sorghum silage, however.

Steers fed the fattening ration containing pelleted sorghum grain made greater average daily gains, consumed less feed per 100 pounds of gain, and produced 100 pounds of gain more economically than steers fed the fattening ration containing cracked sorghum grain. Both of these rations produced greater and more economical gains than the other rations tested.